Our Solar System Through the Eyes of Scientists
Grades 1–3 Lesson 3 (Activities 1–5)

LESSON 3

Space Can Be a Chilly Place — Ice Is Nice!

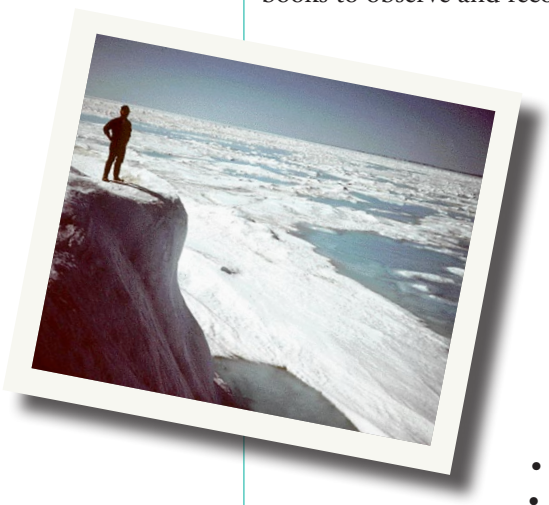
Activity 1 — Pre-Assessment

Activity Time
60 minutes

Picture This!

Introduction for Teachers

What is ice? What does ice become when it melts? Why is ice important? The same thing that melts in your summer sodas is all around us, on our own planet and throughout our solar system. Why is ice interesting? Meet Scientist and Arctic Space Explorer, Ben Holt. Learn with your students about Mr. Holt and what he and other scientists do as they observe and record scientific data about ice — both here on Earth and other places in our solar system. Your students will learn about water ice and how it is found on many objects in the solar system. Your students will learn to think like scientists, using notebooks to observe and record and draw and ask new questions about what they see.



Come In!

What is ice? Where do we find ice on Earth? Do you ever wonder what it looks like in space? What about ice on other planets?

Intended Curriculum

Big Idea

Learning about ice in the solar system through the eyes of Scientist–Arctic Space Explorer, Mr. Ben Holt.

Science Objectives

Students will:

- Learn that water ice is found on numerous objects in the solar system.
- Learn that scientists are looking for water in the solar system as a possible indicator for life forms on other planets and/or moons.
- Practice observation skills to gain information as scientists do.

Language Arts Objectives

Students will:

- Develop and use descriptive vocabulary to record observations.
- Practice identifying main ideas and supporting details in expository text and note taking.
- Develop descriptive vocabulary to create their own expository text.

Materials and Teacher Preparation

Materials

- "Meet the Scientist" segment below
- Colored pencils or crayons
- Pencils
- Science Notebooks
- Solar System folder for each student
- Science Word Wall chart
- "What Scientists Do" chart

Teacher Preparation

- Distribute a Science Notebook and Solar System folder for each student.
- Create evaluation rubrics (see teacher pre-assessment evaluation guidelines)

Meet the Scientist

The Story Begins! Meet Benjamin Holt

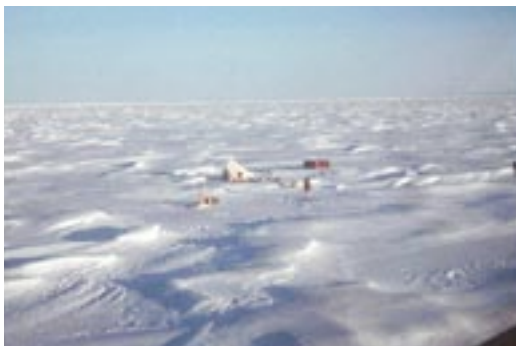
"Ice is nice!" This is what Benjamin Holt, a scientist who studies ice at NASA's Jet Propulsion Laboratory in Pasadena, California, says about ice. An Arctic explorer as well as a scientist, Mr. Holt is very interested in ice here on Earth. His first "field trip" to the Arctic 20 years ago got him interested in ice, and he has been studying it ever since. With other scientists, he hopes to answer many questions about ice, and form more questions!

Why is ice changing here on Earth? Are animals moving because of changes in ice? Where did the birds go that Mr. Holt saw 20 years ago in the Arctic? Are they coming back?

Mr. Holt uses NASA satellites that orbit around and look down on Earth to collect data about ice and how it changes. He uses tools on these satellites to measure things, such as how thick the ice is.

Satellites also explore other planets and get to see ice elsewhere in the solar system. While it's pretty easy to see (and feel how cold it is!) here on Earth, it is more complicated to travel through space and see ice on other planets and moons.

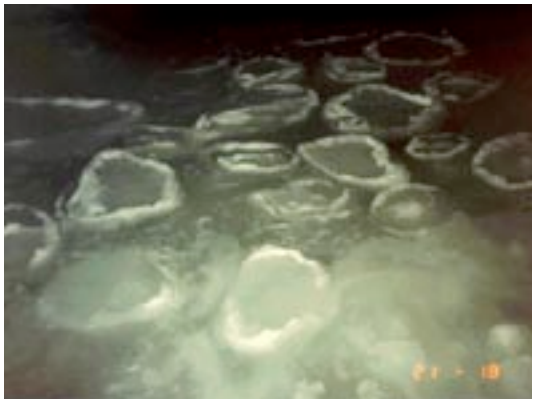
Together with his team, Mr. Holt explores the polar sea cap ice to see how much it changes over time, and why. He also uses microwave remote sensing, a way of "seeing" ice from above Earth to measure its thickness. He also studies ocean currents that affect ice in the frozen seas in the Arctic and Antarctic.



Discussion Prompt

Refer to the Teacher Resource Guide at the end of this activity:

- Why is ice cold? How cold is ice? Why is it important to study ice here on Earth?
- Did you know that there is ice throughout the solar system?
- Ice keeps changing. Why do you think ice changes its shape and size?



Science Notebooks

Let's Begin Our Notebook Activity

Science notebooks are important to being a good scientist, because they help you remember what you see and observe, and what you want to know. As you learn new things, you can add them to your notebook.

When you think about ice, what do you think of? Does all ice come from water? What does ice look like here on Earth? What do you think ice looks like on other planets and objects in the solar system? What does ice feel like? Why is it cold? Why is ice slippery? Why is it rough? Think like a scientist and write down what you think you know about ice here on Earth and in other places in the solar system.

- What do you think a scientist like Mr. Holt might put in his notebook?
- Include drawings and illustrations.

What does ice feel like?

Science Word Wall
These are words placed on a blackboard or other wall to get the students to start thinking about these concepts. As they learn more about the solar system, encourage students to add their own.

First Words for the Science Word Wall

frozen, icy, crystals, surface, edge, face, cube, liquid, cloudy, cracks, bubbles, structures, soil, dirt, salt, clear, melting

Making Meaning

What have you learned?

Using the notebooks, ask students to share their words, pictures, ideas, phrases and sentences.

Some facts to emphasize:
- Ice is found throughout the solar system, from Mercury to the farthest reaches of the solar system.
- Water ice on Earth is the same as in other parts of the solar system.
- Space is cold when you are far from the Sun!
- Water ice has structures that can be described.

What do you think Mr. Holt might have put in his notebook when he began as an Arctic explorer, studying ice? What do you think he might write after measuring and observing ice after many years?

Have students label what they draw in their notebooks.

Refer to the "What Scientists Do" chart: How did this activity help your students think and be like scientists? Compare and contrast chart with student observations, recording, notebook and discussion activities.

Teacher Pre-Assessment Evaluation

Objectives taught in this lesson may be used to create rubrics for evaluating student writing in notebooks and represent the pre-assessment for this unit.
- Learn about water ice and how it is found here on Earth and on many objects in the solar system.
- Take a closer look at ice by creating real ice models to get to know different characteristics of ice such as crystals, bubbles, and other unique ice structures.
- Reflect on students' knowledge and document learning through compare and contrast writing.

Standards

National Science Standards
- Physical Science: position and motion of objects
- Earth and Space Science: objects in the sky
- Physical Science: Properties of Materials
- Physical Science: States of Matter

National Council of Teachers of English (NCTE) Standards for the English Language Arts
- Students read a wide range of print and electronic text to build an understanding of nonfiction and to acquire new information.

- Students apply a wide range of strategies to comprehend, interpret, evaluate, and appreciate texts.
- Students adjust their use of spoken, written, and visual language to communicate effectively with a variety of audiences and for different purposes.
- Students employ a wide range of strategies as they write and communicate with different audiences for a variety of purposes.
- Students conduct research by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data to communicate their discoveries.
- Students use spoken, written, and visual language to accomplish their own purposes for learning, enjoyment, persuasion, and the exchange of information.

Acknowledgments

Richard Shope, NASA's "Exploring Ice in the Solar System," which encouraged us to take a close look at ice and write about what we see — *http://www.messenger-education.org/teachers/MEMS_CompPlanetology.php#mystery*

Margaret Wise Brown's *The Important Book* for innovative ways to describe the wonders of our natural world.

Barbara Lehn for her wonderful book, *What is a Scientist?*

Further Exploration

Take a look at Lesson 7 in this Cassini–Huygens curriculum to see another activity on ice and the rings of Saturn — *http://saturn.jpl.nasa.gov/education/educationK4Program/educationK4Lit12b/*

This website contains excellent background information and student activities — *http://btc.montana.edu/messenger/library/pdf/ice_worlds.pdf*

For more information about ice on Jupiter's moon Europa — *http://solarsystem.nasa.gov/scitech/display.cfm?ST_ID=1789*

This link explains more about ice in very student-friendly terms — *http://spaceplace.nasa.gov/en/kids/ice/index.shtml*

To find out more about how global warming is changing Earth at the poles — *http://www.nasa.gov/vision/earth/lookingatearth/icecover.html*

Find out why scientists are interested in geysers and volcanoes spewing ice and where they have been found in the solar system — *http://www.astrobio.net/news/article2400.html*

Explore Mars and see what it can tell us about our own planet — *http://www.nasa.gov/vision/universe/solarsystem/mars_ice_age.html*

Take a look at this site to find out more about meteorites that have been preserved in Actic ice — *http://curator.jsc.nasa.gov/antmet/metsfromant/index.cfm*

Learn about ice and Earth's Moon — *http://nssdc.gsfc.nasa.gov/planetary/ice/ice_moon.html*

Teacher Resource Guide (3 pages)

B-R-R-R-R—It's Chilly! Where Do We Find Ice in the Solar System?

Well, it's in lots of places, as it turns out. Water ice is, in fact, the most abundant solid compound in the solar system! This guide is not meant to give a definitive listing of all the locations where we have found ice — but it does give an idea of the range of places that scientists have found water ice or other kinds of ice in our solar system. NASA spacecraft are traveling out in the solar system on their way to new planetary destinations. The data coming from this exploration may change our thinking about ice, but for now, here's an overview.

The Oort Cloud — This vast cloud at the outer reaches of the solar system contains billions of icy bodies in solar orbit. Many astronomers think it is the source of long-period comets. Long-period comets have unpredictable orbits with orbital periods much longer than 200 years. They can return after periods of thousands to millions of years (or not at all).

Eris — A Kuiper Belt object slightly larger than Pluto, with a surface covered with methane ice, similar to Pluto. Eris has a small moon named Dysnomia thought to be made of water ice. Eris has been designated a dwarf planet (like Pluto).

The Kuiper Belt — This disk-shaped region lies beyond the orbit of Neptune and contains many small icy bodies. Many scientists think it is the source of short-period comets. These comets have predictable orbits with short orbital periods of return (up to 200 years).

Comets — So-called "dirty-ice" leftovers from the dawn of the solar system; comets have nuclei ontaining icy chunks and frozen gases with bits of embedded rock and dust.

Pluto and its moons — Pluto has a rocky core surrounded by a mantle of ice water; exotic ices like methane and nitrogen frost coat its surface. When Pluto is closer in its orbit to the Sun, these ices thaw, rise, and temporarily form a thin atmosphere. Most of the time, Pluto's atmosphere is thought to be frozen. Charon is a very large moon of Pluto, known to have water ice on its surface. Pluto also has two very small moons named Nix and Hydra.

Neptune and its moons — Neptune's atmosphere extends to great depths, gradually merging into water and other "melted ices" over a heavier, Earth-sized core. Triton, a moon of Neptune, is the coldest body visited by spacecraft in our solar system (thanks to NASA's Voyager 2!) — temperatures on its surface are about –400 degrees F. Despite this deep freeze at Triton, Voyager 2 discovered geysers spewing icy material upward nearly 5 miles.

Uranus and its moons — Uranus is composed primarily of hydrogen and helium with a small amount of methane and traces of water and ammonia. The bulk of it is contained in an extended liquid core consisting primarily of "icy" materials (water, methane, and ammonia) with higher-density materials located deeper within the planet. Uranus has 27 known moons—the inner moons appear to be about half water ice and half rock. Miranda, one of Uranus' moons, has extremely high cliffs and winding valleys and shows indications of melting of its interior, with icy materials occasionally drifting to its surface.

Saturn and its moons — Saturn's glorious rings are made mostly of water ice. Enceladus, one of Saturn's many moons, shows evidence of active ice volcanism. Scientists observed warm fractures where evaporating ice evidently escapes and forms a huge cloud of water vapor over Enceladus' south pole. Iapetus has one side that appears to be white as snow: Does it have ice? That's what scientists think all that brightness on Iapetus might be, since we find few other materials in space that can be so white and bright.

Jupiter and its moons — Jupiter may support a solid core of ice-rock about the size of Earth. Water ice exists deep below and can sometimes be seen through clear spots in the clouds. Two of Jupiter's moons, Europa and Ganymede, both have a core and a rock envelope around the core. Around that is a thin, soft, ice layer and around that is a thin crust of impure water ice. Europa's surface is mostly water ice and there is evidence that it may be covering an ocean of water or slushy ice. Europa is thought to have twice as much water as Earth. Could it be a "habitable zone?" Its surface shows places where ice has broken up and moved apart and where liquid may have come from below and frozen smoothly on the surface. The heat needed to melt the ice in a place so far from the Sun is thought to come from inside Europa, resulting primarily from the same type of tidal forces that drive volcanoes on Io, yet another moon of Jupiter. The layering at Callisto is less well defined than that of Europa and Ganymede, but it appears to be mainly a mixture of ice and rock.

Mars — Mars has polar ice caps that grow and recede with the seasons. Scientists believe that Mars experienced huge floods about 3.5 billion years ago. Though we don't know where the ancient flood water came from, how long it lasted, or where it went, recent missions to Mars have uncovered intriguing hints. NASA's Mars Odyssey orbiter detected hydrogen-rich polar deposits indicating large quantities of water ice close to the surface. If water ice permeated the entire planet, Mars could have substantial subsurface layers of frozen water. One of the Mars Exploration Rovers found structures and minerals indicating that its landing site was once the shoreline of a salty Martian sea. On other parts of the planet, the other Mars Exploration Rover also found signatures of ancient water. It looks like Mars was once a pretty wet place! Scientists are very interested in finding out what happened to all that water.

Earth and its Moon — Earth has lots of ice! We find ice on mountains, in glaciers, icebergs, and winter landscapes in the right locations. We have lots of water ice! Startling results from the Clementine and Lunar Prospector spacecraft indicate that there might be water ice on our Moon. Though the Lunar Prospector did not produce an observable water signature in 1999, the issue of whether ancient cometary impacts delivered ice that is harbored in dark, cold areas of the Moon was still an open question. That is, until NASA's Lunar Reconnaissance Orbiter (LRO) and Lunar Observation and Sensing Spacecraft (L-CROSS) did in fact find water on the Moon in 2009.

Venus — Our current understanding is that there is no ice on Venus, and scientists have found only traces of water in its thick atmosphere. Not a good place to look for a cool drink!

Mercury — In 1991, using radar observations, scientists showed that Mercury may have water at its north and south poles inside deep craters that are perpetually frozen (–350 degrees F). Infalling comets or meteorites might have brought ice to these regions of Mercury, or water vapor might have outgassed from the interior and frozen out at the poles.

So, you can see that space is indeed a chilly place!

For Further Exploration

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LESSON 3

Space Can Be a Chilly Place — Ice Is Nice!

Activity 2 — Try This!

Activity Time
60 minutes

Getting a Closer Look at Ice: Observe and Record It!

Let's take a closer look at ice and observe and record what we see! This hands-on activity will help students understand the different shapes and forms ice can take. They will observe and record characteristics of ice collected in four different containers.

Intended Curriculum

Big Idea

Learning about water ice that is found on numerous objects in the solar system, through the eyes of scientist and Arctic Space Explorer, Mr. Ben Holt.

Science Objectives

Students will:

- Learn that water ice is found on numerous objects in the solar system, and that it is the same on Earth as in other parts of the solar system.
- Learn that scientists are looking for water in the solar system as a possible indicator for life forms on other planets and/or moons.
- Practice observation skills to gain information as scientists do.

Language Arts Objectives

Students will:

- Develop and use descriptive vocabulary to record observations.
- Practice identifying main ideas and supporting details in expository text and note taking.
- Develop descriptive vocabulary to create their own expository text.

Materials and Teacher Preparation

Teacher Preparation — The Night Before

You will need four containers of ice, each with different characteristics, and plates to display the ice. The night before the activity, freeze four containers of ice — one of plain water, one of water containing blue food coloring, one of water containing 2 to 3 tablespoons of dissolved salt, and one of water containing a tablespoon of soil stirred into it.

Teacher Tip

Use disposable plastic containers to freeze the ice samples for your classroom explorations. Larger containers (such as half-gallon or gallon milk containers) can give you surprisingly unique ice! If the ice in the large container is not frozen all the way through, punch a hole in the side and drain the water out.

Remember, ice freezes from the outside in toward the middle and so there may still be some unfrozen parts. The ice crystals can be spectacular!

Materials

- Colored pencils or crayons
- Four different containers of ice that you have prepared previously (as described above) and plates to display the ice
- Glass pie plate or other transparent container
- Magnifying glasses (optional)
- Flashlights for illuminating the ice (optional)
- Overhead projector for ice viewing
- "What Do Scientists Do?" chart
- Science Notebooks

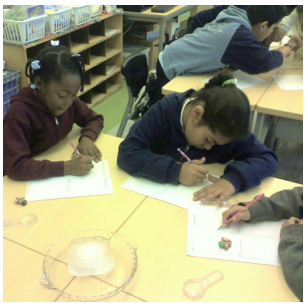
Lesson Procedure

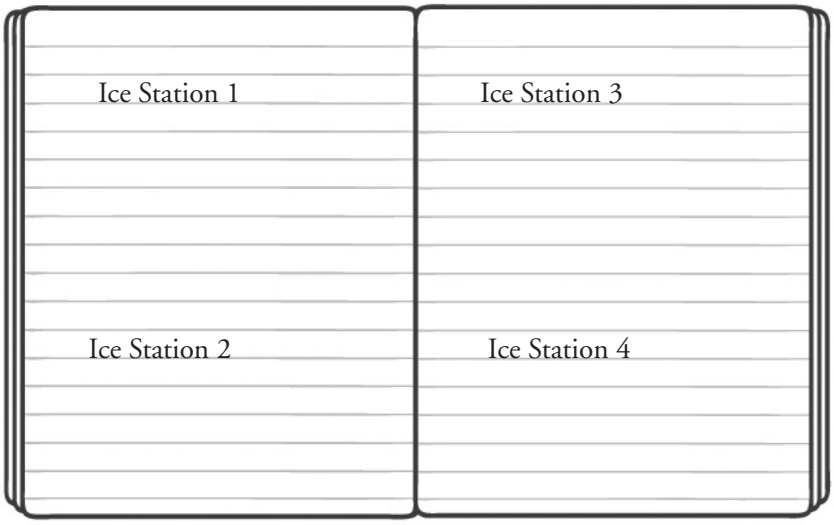
- Set up four stations — one for each ice sample — in your classroom. Remove ice from containers and place each sample on a plate.
- Explain to your students that they will be rotating through the four stations to take a closer look at ice. Refer back to the chart used in previous lessons, "What Does a Scientist Do?" Review the scientific skills your students will use to observe ice and record their observations.
- Ask students to label their drawings — encourage them to be specific with their labels. For example, students may see crystal formations or lines in the ice. Air bubbles should also be recorded as well as any impurities the students find in the ice.
- Begin the first station rotation. Direct students to work and record their observations like a scientist with each rotation.
- Allow about 30 minutes for all four rotations.
- Use the overhead projector to show some of the unique ice structures. Place ice in a transparent container, like a glass pie plate, and put it on the projector's glass surface. Turn on the overhead projector. Have students observe the ice as it is illuminated by the light. Note: Students are not looking at the projected image of the ice, but the ice itself as it is illuminated from below.
- Ask each student to describe in their notebooks what they did, what they saw, what they discovered, and any new questions they have about ice. As they finish their writing, ask students to draw one picture, with color pencil or crayons, of one of the characteristics of ice that they observed.

Science Notebooks

Let's Begin Our Notebook Activity

- Now that you have seen all four ice stations, what did you see? What did you discover about the different ice containers? Ask students to divide their notebook pages into four sections and label each one Station 1 through Station 4. Have them draw what they see in their notebooks. The notebooks can also easily be used to record students' ice discoveries.
- Have students share their ice drawings and also share what words, phrases, sentences and pictures they use to describe ice in their notebooks.





Science Word Wall

formations, ice structures, illuminated

Making Meaning

Have students refer to their notebooks. What are some of the similarities and differences in the different samples of ice that you saw?

Points to Emphasize

- Ice can have many shapes and forms.
- Ice has many unique characteristics, including bubbles, cracks, lines and crystal formations.
- Ice is found in several places in the solar system.
- There is ice on Enceladus, Europa and Mars — and many other places too!
- Water ice on Earth is the same as water ice in other parts of the solar system.

Acknowledgments

Richard Shope, NASA's "Exploring Ice in the Solar System" CD.

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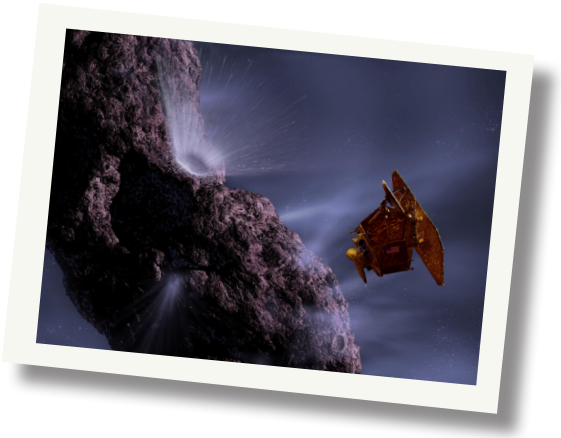
LESSON 3

Space Can Be a Chilly Place — Ice Is Nice!

Activity 3 — Do This!

Activity Time
45 minutes

What Is a Comet?



What is a comet? Comets have sometimes been described as dirty snowballs, snowy dirtballs, or something in between. But what does that really mean? It means that these dirty snowballs are believed to be a cold mixture of frozen water, dry ice, and other sandy or rocky materials left over from the early formation of our solar system. In this activity, students can develop a comet model out of ice cream that they can eat. Like instruments on a spacecraft that collect information and analyze the structure and composition of comets, students will use their four senses individually to decide what is in the ice cream. Most of the ingredients can be found in the home.

Intended Curriculum

Big Idea

Learning about ice in the solar system through the eyes of Scientist–Arctic Space Explorer, Mr. Ben Holt.

Science Objectives

Students will:

- Learn that water ice comes in many forms and is found on numerous objects in the solar system.
- Learn about the structure and composition of comets.
- Learn that scientists are looking for water in the solar system as a possible indicator for life forms on other planets and/or moons.
- Practice observation skills to gain information as scientists do.

Language Arts Objectives

Students will:

- Develop and use descriptive vocabulary to record observations.
- Practice identifying main ideas and supporting details in expository text and note taking.
- Develop descriptive vocabulary to create their own expository text.

Materials and Teacher Preparation

Materials

- Form small research teams of 2 to 4 students. *Survey your class ahead of time for any allergies (milk, peanuts, etc.) to items that you plan to use.*
- Gather the following materials for each team of 2 to 4 students:
  - —One sandwich-size reclosable plastic bag
  - —One gallon-size reclosable plastic bag per team
  - —Small cups for eating ice cream: one for each person on the team and one extra cup for ice cream that will be used for the students to touch

—Plastic spoons
—Pairs of rubber kitchen gloves or cloth towels or sweaters (the comet gets cold!!)
—Ice (crushed or cubes enough to fill a gallon-size bag one-half full per team), or bring in fresh snow from outside
—Chunky cookies in black or brown, crushed candies (like toffee or peppermint), gummy bears, coconut flakes and peanuts
—Whole milk (2% won't work)
—Sugar
—Vanilla extract
—Evaporated milk (or cream)
—Salt (at least a 26-ounce container or a one-pound bag)
—Can opener
—Something to use to crush cookies and other additives

For each student:
- Notebook or paper on which to write down their comet data.

Teacher Tips

- Suggested quantities for large groups — For a class of 20 (10 groups of 2 students each):
  - —3 to 4 cans of evaporated milk: 12 fl oz each
  - —1 gallon of whole milk (you'll have some left over)
  - —20 cookies
  - —¼ lb of sugar
  - —1bag of peanuts and 1 bag of coconut flakes
  - —¼ bottle of vanilla (or leave out this ingredient)
  - —10 sandwich-size reclosable bags (have a couple of extra bags available, just in case)
  - —10-gallon size reclosable bags
  - —2 to 3 containers of table salt (you'll have some left over)
- If the students toss the bags back and forth or bang them against a surface while freezing the ice cream, the bags may break.
- Bring extra dishtowels, cloths, or other insulator for hands to guard against discomfort while students are turning their bags over and over.
- Have a mop available for dripping or spilt water, or do the activity outside.

Lesson Procedure

To begin: Everyone wash hands! You may choose to use food gloves.

Teacher Tip

One person should hold the bag while another pours ingredients into the bag. To cut the activity time, you can premix the milk, evaporated milk, sugar, and vanilla into the small bags and premeasure the salt into the large bags. (You can preload salt into the bags at home.) Make enough sandwich bags of ice cream for each team to have one. To add ingredients, squeeze the air out and seal the sandwich bags carefully each time they are opened.

STEP #1
- Mix into the sandwich-size bag:

One-third cup evaporated milk (or cream)
Two-thirds cup whole milk

5 level spoonfuls of sugar
Less than ¼ tsp of vanilla

Explain the comet connection: Discuss with your class the following ingredients to be added to the ice cream to represent dust (Black/brown cookies in fine and large chunks), rocks (peanuts), carbon dioxide (coconut flakes).

- Have the students begin to add ingredients. Make sure they are also adding some ingredients to represent what we might find in a comet. Possibilities are: gummy bears (early organics for life?) peppermint, toffee, or other ingredients you might choose. Remember to choose food that will not dissolve while the ice cream is setting.
- Close the bags. Squeeze any extra air out of the sandwich bag and close it. Be sure it cannot leak. (Turn it upside down to check.)

STEP #2

- Place the sandwich bag into the bottom of the gallon bag. Put in approximately 10 heaping spoonfuls of salt if you did not preload the salt earlier.

STEP #3

- Fill the gallon bag (containing sandwich bag) at least 1/3 full of ice.

STEP #4

SUGGESTION: Rubber gloves, mitts, cloth towels, or other thick fabric may be needed to hold the bag because it will get extremely cold. Start with bare hands so students can feel the temperature change.

- Close the larger bag tightly to remove as much air as possible. Check for leaks.
- Gently shake and roll the bag while keeping it in constant motion for approximately 6 to 10 minutes or until half the bag has turned to water.
- Gently feel the sandwich bag through the icy mixture. When the milk/sugar mixture in the sandwich bag has hardened into soft ice cream, open the gallon bag and remove the sandwich bag containing the ice cream.

STEP #5

- Direct students to trade their comets with other teams so the ingredients are a mystery. Each team should briefly rinse the outside of the sandwich bag they were given with fresh water before opening so that no salt flavor is transferred to the ice cream.
- Split the ice cream comet by spooning some into the cups provided, one for each team member. Make one extra cup and put it aside. Don't eat this one!

STEP #6

Explain to students: A spectrometer takes different kinds of data through different filters. Pretend that your eyes, hands, and taste buds are scientific instruments taking data from your "comet." Take the following "data" and record it on a data sheet or in a notebook:

- Look at the "comet" and see what you can observe visually.
- Take the extra cup laid aside and have each team feel the contents. Write down what you feel.
- Smell the ice cream and see if you find any additional information.
- Taste the ice cream and record any final information about what is in it. Compare your results with the team that made the ice cream you tasted.
- Record what you discovered as you watched the elements in the bag become ice cream.
- Share your conclusions about your comet with your class.

Discussion Prompt

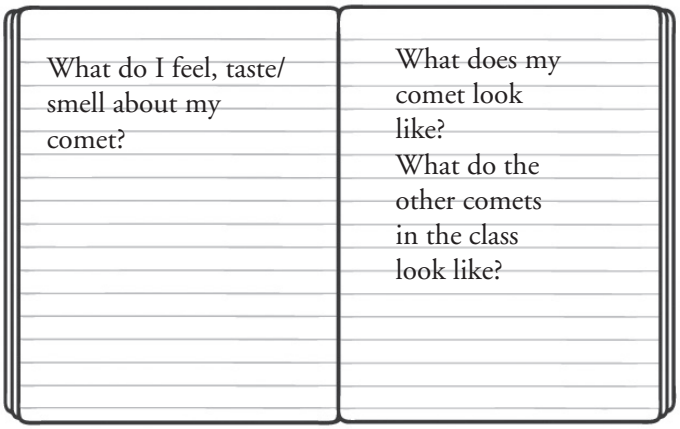
Throughout history, scientists have used different methods of observation and testing to find out more about comets. In the same way that Mr. Holt does when he studies ice here on Earth, scientists look into the sky and apply what they know about math, science, and finally technology to further study these icy travelers. Now we have the ability to visit comets, with spacecraft like Stardust and Deep Impact. Scientists are always careful to record their observations and data. They use this research to build models to test and confirm their theories about comets.

Science Notebooks

Let's Begin Our Notebook Activity

Have students write and draw what they see in their science notebooks. Use one page for writing and the opposite page for drawing about what they have touched, smelled, and tasted after creating their comets.

- What can you discover about your ice cream "comet" using your sight, touch, smell, and taste "filters" as though you were an instrument on a spacecraft?
- What visual observations do you make about your ice cream comet?
- Take the cup you laid aside. Don't taste this one. What are you able to tell by using your fingers to feel the ice cream comet?
- What are you able to tell about your comet using only your sense of smell?
- What are you able to tell about your comet adding your sense of taste? What explanations do you draw about the composition of your comet?



Science Word Wall

comet, observation, filters, sense

Making Meaning

Have students refer to their Science Notebooks.

What have you learned?

Key Concepts

- Comets are cold.
- Comets are partially made of ice and have debris from the formation of the solar system, although we have much to learn about how they behave.
- Comets have two tails — one is made of gas and one is made of dust. The tails always point away from the Sun as the comet travels.

Direct students to share their notebooks about what they "sensed" about their own comet and what they observed when they compared theirs to other classmates' comets. Show them an image of a real comet (see Resource Material).

Acknowledgments

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Maura Rountree-Brown, Jet Propulsion Laboratory — *Maura.Rountree-Brown@jpl.nasa.gov*

Further Exploration

"Make a Comet and Eat it!" — *http://solarsystem.nasa.gov/educ/docs/Make_A_Comet.pdf*

Background information on comets — *http://solarsystem.nasa.gov/planets/profile.cfm?Object=Comets*

Standards

National Science Education Standards

- Personal Social Connection
- Nature and History of Science
- Unifying Concepts and Processes

Curriculum Content Standards

- Size, Scale and Properties of Solar System Objects
- Energy: Nature of and Properties

More information about comets:

"Consider This": This page shows the history of perceptions about comets —
http://solarsystem.nasa.gov/deepimpact/educ/ExploringComets03.html

"A Comet's Place in the Solar System": A little history about where comets came from —
http://solarsystem.nasa.gov/deepimpact/educ/ExploringComets04.html

"Ten Important Comet Facts": A quick review of comet facts —
http://solarsystem.nasa.gov/deepimpact/educ/CometFacts.html

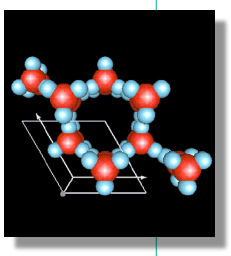
"The Deep Impact Comet Acrostic: Good for younger students or comet quick fact reference —
http://solarsystem.nasa.gov/deepimpact/educ/CometAcrostic.html

"Deep Impact Interesting Mission Facts": Some fun facts about NASA's Deep Impact mission —
http://solarsystem.nasa.gov/deepimpact/educ/DIFacts.html

"Small Bodies Missions": Learn about Deep Impact and about other missions to comets and asteroids —
http://solarsystem.nasa.gov/deepimpact/science/smallbodies.cfm

Teacher Background Material (2 pages)

The Chemistry and Thermodynamics of Ice Cream



This picture was created at the Institut Laue-Langevin, an international research center and world leader in neutron science and technology, based in Grenoble in southeast France. The image shows an ice crystal. The crystal is made of many molecules of water (H_2O. The atoms are shown by different colors. The darker atoms are oxygen; the lighter atoms are hydrogen. The hydrogen atoms are attached at an angle near 120 degrees.

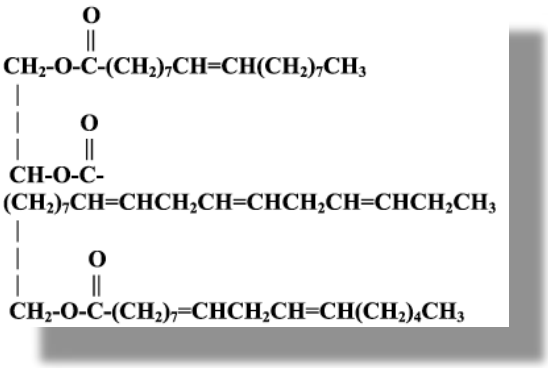
The hydrogen atoms are attracted to each other and form hexagonal rings in all directions. As ice crystals or snowflakes grow, they expand by attaching new water molecules to each other. Looking at them with a hand lens or microscope tells us about how they join together. The angles are always the same so the designs always have six sides. Whether ice crystals or snowflakes, observing the shape under atomic microscopes reveals a shape that is always hexagonal.

If the angle had been different, the shape would have been different. Salt crystals (NaCl) are made of two elements, sodium (Na) and chlorine (Cl), which join at 90-degree angles. Under a hand lens or microscope, the crystals of salt appear as little dice or cubes. The shape of the crystal is determined by the angle of chemical bonding (joining together).

What does "ice" have to do with "ice cream"?

Here is a typical triglyceride butterfat molecule from which ice cream is made. Ice cream is formed when many tiny ice crystals form between the "arms" of the triglyceride butterfat molecule.

Extensions: Chemistry, Crystals, and Calories



1. Look at the drawing of the butterfat molecule. The letters stand for chemical elements joined together in long chains. You can make a model of the molecules with gumdrops and toothpicks.
2. Make up a code and assign each element (gumdrop) a color. The elements are:
   Carbon (C) Color:
   Oxygen (O) Color:
   Hydrogen (H) Color:

3. Build the molecule with groups assembling a part of a chain. Connect them with toothpicks. The toothpicks represent chemical bonds: the glue that holds elements together in molecules. The symbols "=" or "||" mean use two toothpicks. These are called double bonds in chemistry. Then lay them out and connect the whole butterfat molecule on the floor or table.
4. At the same time, make lots of water (H_2O) molecules (oxygen is in the middle, with two hydrogens, one on each side like a boomerang) and oxygen molecules (O_2). Lay the water molecules between the long chains of the butterfat. Now "freeze" them by connecting three boomerang-shaped water molecules together in a hexagon shape, touching the hydrogen atoms together.
5. Why does ice cream make people gain weight? After you eat ice cream, the only way to get rid of it is to "burn" it out of your body. That involves the same idea as burning a match (fuel + oxygen), except this burning is flameless. The ice cream is the fuel and the air you breathe gives you oxygen.
6. "Burn" the ice cream by using the oxygen molecules you made. Oxygen breaks ice cream apart by attacking and breaking the toothpicks and carrying away the hydrogen and carbon. Here is the formula:

— C + O_2 makes one CO_2 (carbon dioxide you breathe out)

H + H+O makes one H_2O (water) which you breathe out (for example, cold morning breath)

7. How many oxygen atoms does it take to carry away the butterfat molecule? This is why "aerobics" is a good idea for weight loss: it makes you fill your body with lots of oxygen to "burn" the butterfat, releasing "heat" measured in calories (a way of measuring energy content).

This is Comet West, photographed by the Observatoire de Haute, Provence, France.
http://apod.nasa.gov/apod/image/comet_west.gif

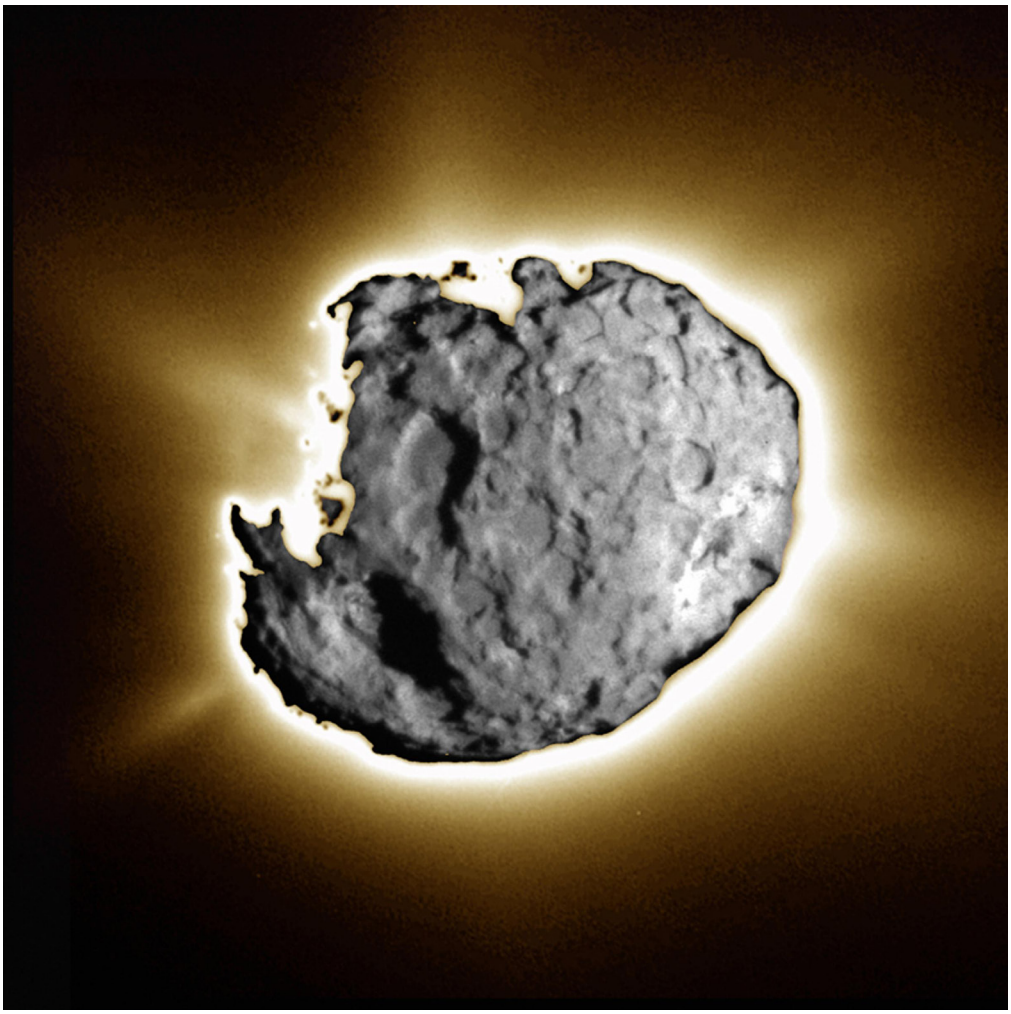
Comet West

1 per student

This is Comet Wild 2 as seen by NASA's Stardust spacecraft.
http://photojournal.jpl.nasa.gov/jpeg/PIA05578.jpg

Comet Wild 2

1 per student



LESSON 3

Space Can Be a Chilly Place — Ice Is Nice!

Activity 4 — Read All About it!

Activity Time
30 minutes

Why Is Ice Important?

Intended Curriculum

Big Idea

Learning about ice in the solar system through the eyes of Scientist–Arctic Space Explorer, Mr. Ben Holt.

Science Objectives

Students will:

- Learn that water ice is found on numerous objects in the solar system, and that ice looks different on Earth compared to some other parts of the solar system.
- Learn that scientists are looking for water in the solar system as a possible indicator for life forms on other planets and/or moons.
- Practice observation skills to gain information as scientists do

Language Arts Objectives

Students will:

- Learn to read and understand expository text.
- Use accurate language to communicate their scientific understanding orally and in writing.

Materials and Teacher Preparation

Materials

- A copy of "Space Can Be a Chilly Place —Why Is Ice Important?" reader for each student
- Science Notebooks
- Solar System Folder for each student
- Science Word Wall Chart

Teacher Preparation

Make copies of the "Space Can Be a Chilly Place — Why Is Ice Important?" reader for each student. Have other materials ready.

Lesson Procedure

- Distribute a reader to each student and read it aloud.
- Explain key terms and compare and contrast ice found here on Earth and farther out in the solar system. Explain the difference between water ice in seas near the North and South Poles and ice found in space, as seen through the eyes of Scientist–Arctic Space Explorer, Mr. Ben Holt.

Why Is Ice Important?

Why Is Ice Important? reader (4 pages)

1 per student

Ice is found in many places on Earth. There are ice caps and sea ice at the North Pole and the South Pole. Scientist-Arctic Space Explorer Ben Holt uses information sent by satellite to his computer about the frozen seas here. "Sea ice is really important to study because it helps us understand changes in Earth's climate," he says.

We can freeze water whenever we need ice.

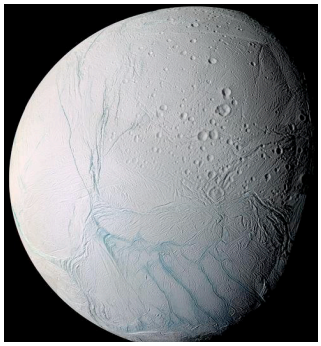
Some of Earth's mountain tops have ice all year long. Many places on our planet have snow in the winter. And, we make ice in our freezers. When is the last time that you saw or used ice?

Ice Around the Solar System
Some ice in the solar system looks different than on Earth. It is colder and harder. Ice on Earth is like grains of ice pressed together with a thin film of liquid water surrounding each grain. Most ice is different in space. It is rock hard with no trace of liquid water. It is frozen solid. Water ice freezes differently in space because it is colder.

These are sheets of ice on Europa, a moon of Jupiter.

Could Life Exist Out There?

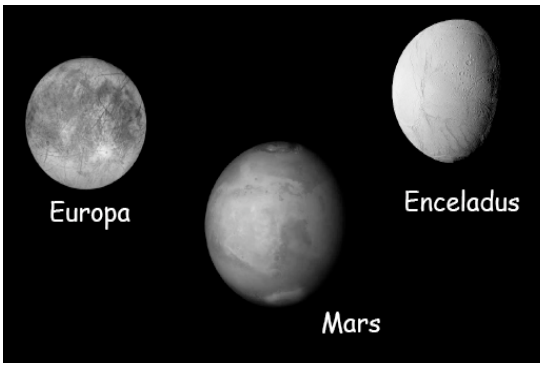
Scientists like Mr. Holt wonder if it is possible for other planets or moons to have life. They think that to be able to have life like on Earth, a planet or a moon must have liquid water or ice. There is no planet or moon with just the right temperatures, like Earth, that could have life that is easy to find. First, scientists have to find water ice.



Enceladus, a moon of Saturn, has ice and water.

Where Else Can We Find Water Ice?

Water ice can be found in most places in the solar system. There are three interesting objects besides Earth that have water ice. They are the planet Mars; Europa, a moon of Jupiter; and Enceladus, a moon of Saturn. Why do you think scientists like Mr. Holt would be curious about water or water ice in the solar system?

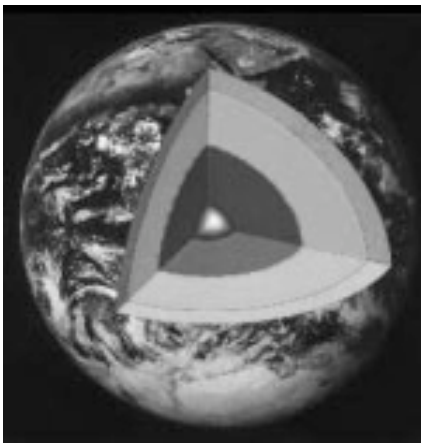


The planet Mars, the moon Europa and the moon Enceladus.

Ice, Oceans and Life?

Scientists are looking for an active planet or planetary moon that is like Earth to find life. An active planet or moon would mean that the planet or moon is changing in the core and on its surface. Mr. Holt studies sea ice in Earth's oceans to better understand when, where and how ice freezes and melts to better understand polar ice on other planets or moons. An active planet or moon could have warmer areas under the rock-hard ice, like an underground ocean. The warmth could keep the water from freezing solid, which could be needed for life. Scientists think that this life would be very small. Microscopic!

Can you imagine life so small you can only see it with a microscope? That is the kind of life scientists are looking for on moons and planets. Some people think they will find it. Other people don't think it is possible. What do you think? So far, no life has been found on moons and planets in our solar system, except on our home planet, Earth!



An active core could keep water from freezing.

Scientists believe that if life were found on other planets or moons, it would be microscopic.

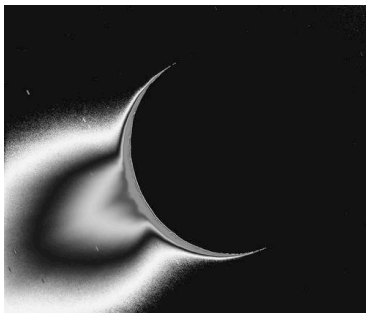
Sea Ice Here, Sea Ice There

Besides studying sea ice on Earth, scientists are very interested in Mars, Europa, and Enceladus. They have active, changing cores, and they have ice! Scientists think that Mars once had liquid water. They have found changes in the landscape that looks like water might have caused the changes.

This picture of the surface of Mars looks like water has flowed there.

Shooting Geysers and Moving Ice Sheets

Scientists found ice streaming out of Enceladus, a moon of Saturn. This makes them think there is water far below the surface. Europa, a moon of Jupiter, is known to have huge water ice sheets. What do you think Mr. Holt might use to compare Earth's ice to ice found at Mars, Europa or Enceladus? Scientists think there could be water under the ice sheets. Do you thinks there is water and life on other planets or moons?



The geysers on Enceladus shoot pieces of ice into space.

Europa is an active moon with moving ice sheets.

LESSON 3

Space Can Be a Chilly Place — Ice Is Nice!

Activity 5 — What Is Ice Like?

Activity Time
45 minutes

Write the Story!

Introduction for Teachers

What have your students learned about ice, both here on Earth and around the solar system? What are some of the characteristics of ice here and on planets and moons such as Mars, Europa, and Enceladus? Help your students write a compare and contrast essay. What is the most amazing thing your students have learned about ice? What have they learned about comets? What have your students learned about Mr. Ben Holt? Students can use their science notebooks to write about what they now understand about ice, based on their own observations and thinking about the different activities from this lesson.

Intended Curriculum

Big Idea

Learning about ice here on Earth and throughout the solar system through the eyes of Scientist–Arctic Space Explorer, Mr. Ben Holt.

Science Objectives

Students will:

- Synthesize all the scientific information they have learned about ice, both here on Earth and elsewhere in the solar system through the eyes of Scientist–Arctic Space Explorer, Mr. Ben Holt.

Language Arts Objectives

Students will:

- Read and understand information.
- Reflect on and recognize their own learning through notebooks.
- Use accurate language to communicate their scientific understanding orally and in writing.

Materials and Teacher Preparation

Materials

- "Space Can Be a Chilly Place — Why Is Ice Important?" reader for each student
- Pencils
- Science Notebooks
- Solar System Folder for each student
- Science Word Wall Chart
- "What Scientists Do" chart

Lesson Procedure

- Hand out a copy of "Space Can Be a Chilly Place — Why Is Ice Important?" reader to each student.

- Select students to re-read "Space Can Be a Chilly Place — Why Is Ice Important?" aloud to the rest of the class.
- Review the Science Word Wall and ask students to refer to their notebooks to help define the words and add new ones.
- Discuss Mr. Holt's exploration of sea ice at Earth's North and South Poles.
- Direct students to write about what they think is the most amazing thing about ice.
- Direct students to write one thing they learned about ice, how it freezes and melts, and what they think about water ice and life on other planets and moons. Encourage them to draw pictures.

Science Notebooks

Let's Begin Our Notebook Activity

Science notebooks are important to being a good scientist, because they help you remember what you see and observe, and what you want to know, As you learn new things, you can add them to your notebook.

Direct students to go back to the first page of their notebooks:

- What did you think about when you thought of ice?
- What do you think caused ice to form here on Earth?
- What about how it formed in other places in the solar system?

Then direct students to go to the last page of their notebooks:

- What do you know about Mr. Holt and his exploration of sea ice at Earth's North and South Poles?
- What are some new things you have learned about ice?
- What do you think about water ice and the possibility of life on other planets and/or moons in the solar system?

Teacher Post-Assessment Evaluation

Concepts taught in this lesson can be used to create rubrics for evaluating student writing and comprehension through their notebooks.

Use the student writing and discussion to assess the extent to which they accurately observed and understood key concepts about ice through the eyes of Mr. Ben Holt.

Key Concepts

- Ice is found in several places in the solar system.
- Ice is found not only on Earth — but also on Mars, Europa, and Enceladus.
- Water ice on Earth looks different than water ice in other parts of the solar system.
- Water ice in the solar system is colder and harder that the ice we have on Earth.
- Space is really cold when you are far from the Sun!
- Water has ice structures that can be described.

"WHAT SCIENTISTS DO" CHART

What do I do that is like Ben Holt?

Predictions About What Scientists Do	What Scientists Do	How We Were Like Scientists
Find answers	Often work in groups	Worked in groups
Work in labs	Ask questions	Collected data, wrote in notebooks
Invent things	Read other scientists' work	Used evidence to discuss what we saw
Mix things together	When they disagree, they look for more evidence	Discussed observations and read books by other scientists